Since the volume of the cell is equal to the cube of its side, the volume of the cell is $(0.407\ nm)^3 = 0.0674\ nm^3$.

2. Silver crystallizes in a body-centered cubic structure (BCC) with a side length of 0.41 nm. What is the atomic radius of a silver atom? What is the volume of a unit cell? If the mass of the unit cell is 7.2×10^{-22} g, what is the density of the cell in g/cm^3? **(E6)**

SELF-TEST

A. Multiple Choice:

1. The critical temperature of methane is –82°C. This means that methane
   a. boils at –82°C.
   b. can never be a liquid at room temperature.
   c. can never be a liquid at –95°C.
   d. contains strong hydrogen bonds.

2. Which of the following shows hydrogen bonding?
   a. CH_4 **b.** H_2 **c.** H_2O
   d. all of these **e.** none of these

3. For a molecular substance, which of the following is NOT true?
   a. The heat of vaporization (ΔH_{vap}) is a measure of the strength of the intermolecular forces in a liquid.
   b. The lower the melting point of a solid, the weaker are the intermolecular forces in general.
   c. ΔH_{vap} may be obtained from a plot of ln P vs 1/T.
   d. The critical point defines the temperature above which a gas may not be liquefied, no matter how great the pressure.
   e. The pressure of the vapor above a liquid depends upon the volume of the container.

4. A solid melts at 75°C. It is insoluble in water and does not conduct electricity in solution, as a solid, or in the molten state. The compound is most likely
   a. metallic **b.** ionic **c.** molecular **d.** network covalent

5. Which of the following statements is true?
   a. C_2H_5OH contains hydrogen bonds but water does not.
   b. Ionic compounds generally have higher melting points than molecular compounds, because ionic bonds are weak compared to the intermolecular bonds in molecular compounds.
   c. Since Ne has larger dispersion forces than He, neon has a higher boiling point.
   d. All of the above statements are true.
   e. None of the above statements are true.

6. The boiling point of carbon tetrachloride, CCl_4, is 77°C, while that of chloroform, $CHCl_3$, is 61°C. This is because
   a. the gravitational attraction between CCl_4 molecules is greater than that of $CHCl_3$.
   b. CCl_4 is polar and $CHCl_3$ is not.
   c. $CHCl_3$ has hydrogen bonding.
   d. the dispersion forces in CCl_4 are greater than the combined dispersion forces in $CHCl_3$.

7. A solid is in equilibrium with its vapor at a certain temperature and pressure. As the volume of the system is decreased while maintaining equilibrium, which of the following is(are) true?

   (1) The pressure goes down.
   (2) The pressure goes up.
   (3) Solid sublimes.
   (4) Gas is converted to solid.

   a. (2),(3) **b.** (1),(3) **c.** (3) **d.** (4) **e.** (2),(4)

8. Which of the following is(are) true?

   (1) critical temperature < triple point temperature
   (2) critical temperature > triple point temperature
   (3) critical pressure < triple point pressure
   (4) critical pressure > triple point pressure
   (5) critical temperature = triple point temperature

   a. (3) **b.** (2),(3),(5) **c.** (2),(4) **d.** (1),(3) **e.** (1),(2),(5)

9. How many of the following groups correctly list the compounds in order of *increasing* boiling point?

   (1) $CH_3CH_2CH_2CH_3 < CH_3CH_2CH_2OH < CH_3CH_2OCH_3 < OHCH_2CH_2OH$
   (2) $H_2S < H_2Se < H_2Te < H_2O$
   (3) $CH_4 < CH_3CH_3 < CH_3CH_2CH_3 < CH_3CH_2CH_2CH_3$

   a. 0 **b.** 1 **c.** 2 **d.** 3

10. How many of the following are molecular substances?

    Na_4SiO_4 SiO_2 Fe I_2 H_2O C (graphite)

    a. 1 **b.** 2 **c.** 3 **d.** 4 **e.** 5 **f.** 6

B. Fill in the blanks:
Write the compound with the *higher* boiling point in the blanks provided.

_____ **1.** C_2H_5OH or C_4H_{10}

_____ **2.** H_2O or H_2S

_____ **3.** Br_2 or ICl (iodine chloride)

_____ **4.** NaCl or SCl_2

_____ **5.** C_3H_8 or $C_{12}H_{26}$

_____ **6.** HF or HCl

C. True or False:

1. KNO_3, an ionic solid

_____ **a.** does not conduct electricity.

_____ **b.** is soluble in water.

_____ **c.** can conduct electricity when the solid is melted.

_____ **d.** has covalent bonds in its structure.

_____ **e.** has an equal number of cations and anions when dissolved in water.

2. The boiling point of ammonia (NH_3) is –33°C, while the boiling point of phosphine (PH_3) is –87.7°C. Ammonia has a higher boiling point because

_____ **a.** the molar mass of NH_3 is less than that of PH_3.

_____ **b.** dispersion forces for NH_3 are stronger than those for PH_3.

_____ **c.** NH_3 is hydrogen bonded while PH_3 is not.

_____ **d.** NH_3 is polar while PH_3 is not.

_____ **e.** NH_3 is ionic while PH_3 is not.

3. The normal boiling point of a liquid

_____ **a.** is the only temperature at which liquid and vapor are in equilibrium.

_____ **b.** is the temperature at which the vapor pressure is 1.00 atm.

_____ **c.** varies with atmospheric pressure.

_____ **d.** is the temperature at which the vapor pressure equals external pressure.

_____ **e.** can be reduced by increasing the pressure.

D. Less than, greater than, Euqal to:

Answer the questions below, using **LT** (for *is less than*), **GT** (for *is greater than*), **EQ** (for *is equal to*), or **MI** (for *more information required*) in the blanks provided.

_____ **1.** At 50°C, benzene has a vapor pressure of 269 mm Hg. A flask that contains both benzene liquid and vapor at 50°C has a pressure (1) 269 mm Hg

_____ **2.** Ether has a vapor pressure of 537 mm Hg at 25°C. A flask that contains only ether vapor at 37°C has a pressure (1) 537 mm Hg.

_____ **3.** The boiling point of H_2O_2 (1) the boiling point of C_3H_8.

_____ **4.** The energy required to vaporize liquid bromine (1) the energy required to decompose Br_2 into Br atoms.

_____ **5.** The dispersion forces present in naphthalene, $C_{10}H_8$, (1) the dispersion forces present in butane, C_4H_{10}.

E. Problems:

1. A certain element crystallizes in a body-centered cubic cell. It has an atomic radius of 0.186 nm.

a. What is the length of one side of the cell?

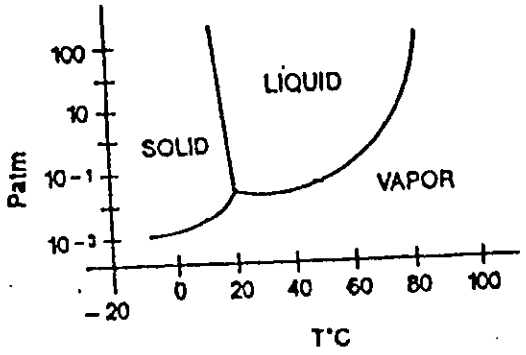
b. What is the volume of the unit cell in cm^3?

2. The vapor pressure of water is 17.5 mm Hg at 20°C. Calculate the heat of vaporization of water.

3. Substance X has a vapor pressure of 175 mm Hg at 25°C.
   a. Substance X is placed in a 15-L tank with a pressure gauge that registers 100 mm Hg at 25°C. What phase(s) of substance X is(are) in the tank?

   b. Substance X is transferred from the 15-L tank to a 30-L tank at the same temperature with no loss of the substance. What phase(s) is(are) present in the tank at equilibrium? Support your answer with calculations.

4. Given the following hypothetical phase diagram:



   a. Which phase (solid or liquid) of this substance is the denser phase?

   b. Describe any phase changes that would occur if the following sequence of steps was followed:
   At constant temperature, the vapor at 60°C and 0.001 atm is compressed to 100 atm and then cooled to −100°C. Keeping the temperature at −100°C, the pressure is gradually reduced until it is 10^{-4} atm.

c. Describe any phase changes that would occur if solid is gradually heated at a constant pressure of 0.01 atm from a temperature of 10°C to 60°C.

ANSWERS

Exercises:

(E1) Br_2 tank: liquid and gas, 46.0 g gas; Cl_2 tank: only gas, 3.6×10^2 g gas
(E2) 159 mm Hg
(E3) It goes from gas to solid.
(E4) no change
(E5) CO_2 — dispersion forces; HF — H–bond, dipole and dispersion forces
BrCl — dipole and dispersion forces.
(E6) r = 0.18 nm; V = 0.069 nm^3; density = 1.0×10 g/cm^3

Self-Test

A. Multiple Choice:

1. b	**2.** c	**3.** e	**4.** c	**5.** c
6. d	**7.** d	**8.** c	**9.** c	**10.** b

B. Fill in the Blanks:

1. C_2H_5OH	**2.** H_2O	**3.** ICl	**4.** NaCl	**5.** $C_{12}H_{26}$
6. HF				

C. True or False:

1. a) T	**b)** T	**c)** T	**d)** T	**e)** T
2. a) F	**b)** F	**c)** T	**d)** F	**e)** F
3. a) F	**b)** T	**c)** F	**d)** F	**e)** F

D. Less than, Greater than, Equal to:

1. EQ	**2.** MI	**3.** GT	**4.** LT	**5.** GT

E. Problems:

1. a. 0.430 nm **b.** 7.95×10^{-23} cm^3

2. 4.28×10^4 J/mol

3. a. all gas **b.** all gas

4. a. liquid **b.** vapor to liquid to solid to vapor **c.** solid to vapor